

#### **Better Understanding of Complex Sites**

Presented By
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#### **Objectives**

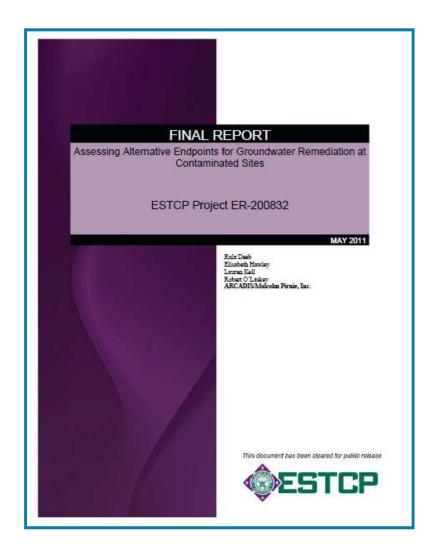


- Discuss challenges complex sites pose to the ER,N Program
- Describe technical and non-technical attributes of complex sites
- Discuss commons themes from Portfolio Optimization that relate to complex sites
- Describe Adaptive Site Management as means of managing site uncertainty and complexity
- Provide examples from complex Navy sites (including follow-up presentation)

# Alternative Endpoints and Complex Sites



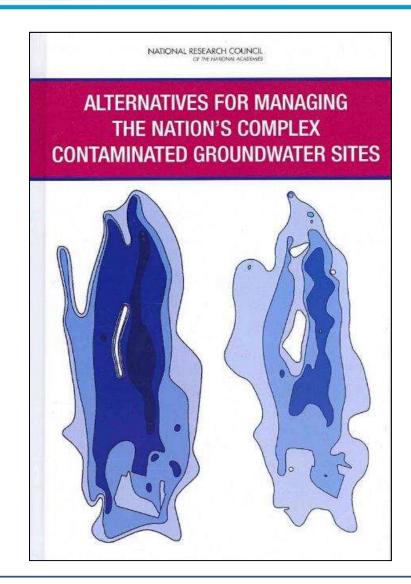
- 2008-11 Malcolm Pirnie-led project to develop alternative endpoints and approaches
- Follow up to previous project for Army (2002-04) on analysis of CERCLA TI waivers



## 2013 NRC Report on Complex Sites



- National Research Council report on managing the nation's complex sites
- Team of experts from industry, academia, and government
- Estimated roughly 10% of sites are "complex" and will not meet cleanup objectives in reasonable timeframe
- Estimated cost to remediate ~\$127 billion
- More detailed guidance needed to manage these sites



### NRC 2013 on Achieving Site Closure



"...at complex sites
characterized by multiple
contaminant sources, large
past releases of chemicals, or
highly complex geologic
environments, meeting the
DoD's ambitious programmatic
goals for remedy in
place/response complete
seems unlikely and site closure
almost an impossibility."

"...the Committee has concluded that regardless of the remedial technologies applied at complex sites, removal of sufficient mass to reduce contaminant concentrations in groundwater to levels that allow for unlimited use and unrestricted exposure is unlikely for many decades."

# NRC 2013 on Breakthrough Technologies



"Furthermore, no transformational remedial technology or combination of technologies appears capable of overcoming the inherent technical challenges to restoration at these complex sites."

"Rather, the nation's cleanup programs are transitioning from remedy selection into remedy operation and long-term management (LTM), potentially over long timeframes."

## **NRC 2013 on Closure Endpoints**



"...transitions of a site to one of three possible "end states," where this term simply means a state where long-term management will be implemented if required. These "end states" are (1) closure in which unlimited use/unrestricted exposure levels have been obtained... (2) long-term passive management (e.g. MNA, PRBs..), and (3) long-term active management (e.g. indefinite hydraulic containment using pump and treat...)"

### 2014-17 ITRC Complex Sites Team



- 2017 ITRC Complex Site
   Definition "Remediation
   progress is uncertain and
   remediation may not achieve
   closure or even long-term
   management within a
   reasonable time frame"
- "Reasonable time frame" for restoring groundwater resource to beneficial use is subject to interpretation and depends on site circumstances



Source: ITRC Remediation Management of Complex Sites

# Site Challenges/Complexities



Technical Challenges	Examples	Non-Technical Challenges	Examples
Geologic conditions	Fractured bedrock, karst geology, low- permeability sediments	Site objectives	Deviations from promulgated screening values or closure criteria (e.g. MCLs)
Hydrogeologic Conditions	Groundwater table fluctuations, groundwater-surface water interactions	Managing changes that may occur over long time frames	Phased remediation, multiple PRPs, loss of institutional knowledge
Geochemical Conditions	Low/high pH, alkalinity, elevated electron acceptors	Overlapping regulatory responsibilities	Federal/state cooperation, numerous stakeholders
Contaminant- related Conditions	LNAPL/DNAPL, emerging contaminants, back diffusion	Institutional controls	Tracking and managing ICs, enforcement
Large-scale site	Size and depth of plume, number and variety of receptors	Changes in land use	Site access, redevelopment, land/water use change
		Funding	Uncertain funding, politics

#### **Polling Question**



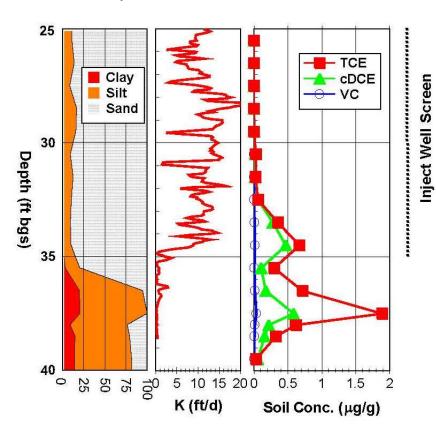
What is the biggest challenge associated with your "Complex Site"?

- A) Site geological conditions (e.g. fractured rock)
- B) Contaminant cond. (e.g. DNAPL, back diffusion, dilute plume)
- C) Unreasonable RAOs (e.g. MCLs on non-potable aquifer)
- D) Change in land use (e.g. re-development, BRAC)

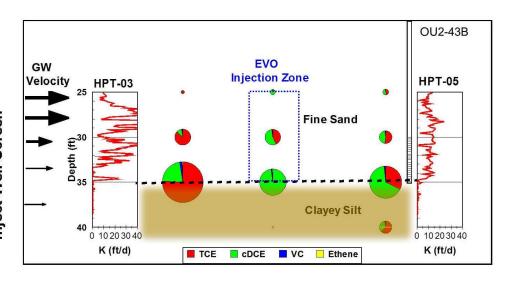
### **Back Diffusion Example**



#### **OU2, Former NTC Orlando**



Source: ESTCP 201581-PR



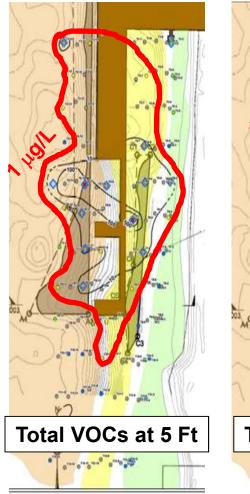
- •TCE and daughter products stored in low permeability silt layer
- Bio-barrier injection wells screened only in overlying sand unit
- Back diffusion likely contributing to long-term plume persistence

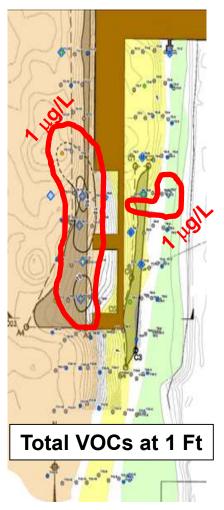
#### **GW/SW Interaction Example**



#### Site 9, NAS North Island

- Complex chlorinated solvent plume discharging into San Diego Bay
- Higher concentrations in 5-ft samples than 1-ft samples
- Natural attenuation driven by biological degradation
- Seepage meters, geochemical evaluation of pore water, microcosm studies



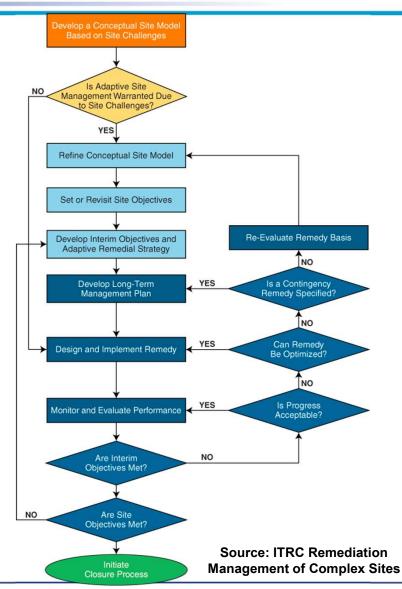


Source: NAVFAC SW 2017

#### **Adaptive Site Management**



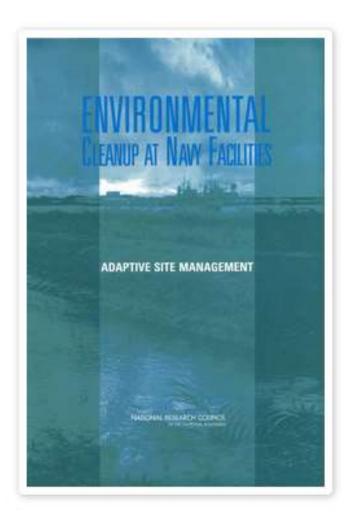
- Identify complexity within CSM
- Refine CSM
- Set or re-visit site objectives
- Develop interim objectives
- Adaptive remedial strategy
- Transition Assessments
- Maintain protectiveness and prevent exposure over long time frames



## 2003 NRC Adaptive Site Management



- NRC study on latter stages of contaminated site cleanup at Navy installations
- NRC committee proposed comprehensive and flexible approach – "Adaptive Site Management"
- Express recognition that system responses will be monitored, interpreted, and used to adjust approach in iterative manner over time

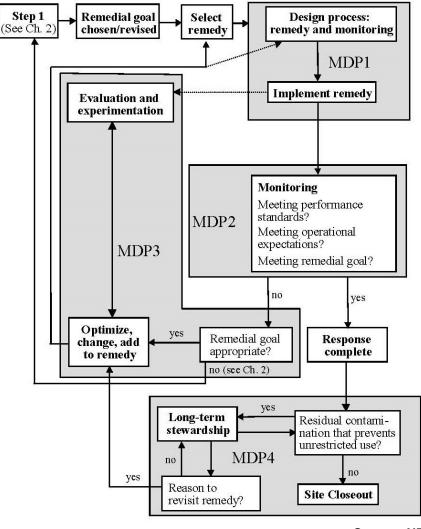


Source: NRC 2003

## **2003 NRC Adaptive Management**



- Multiple feedback loops to address site uncertainty
- Decision points to evaluate incoming data from pilot studies, changes in regulatory criteria, long-term monitoring data, etc.

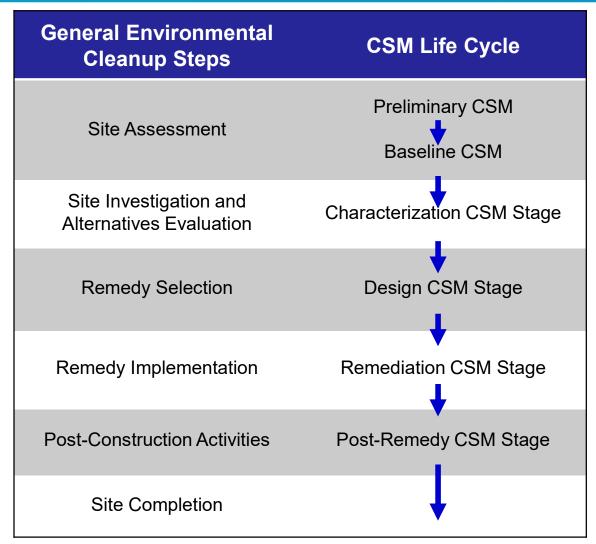


Source: NRC 2003

# Life-Cycle Conceptual Site Model



- Management tool used to make site management decisions
- Dynamic tool that evolves with the restoration process
- More quantitative as site management process matures



Source: EPA 2011

### **Types of Cleanup Endpoints**





Established by regulation

**ARARs** 

**Risk-based objectives** 

**Other Alternative Endpoints** 

MNA over extended timeframes Adaptive Site Management

#### **Alternative**

**ARAR** waivers

State designations and programs

**Groundwater** reclassification

Alternate concentration limits (ACLs)

Source: Navy 2016

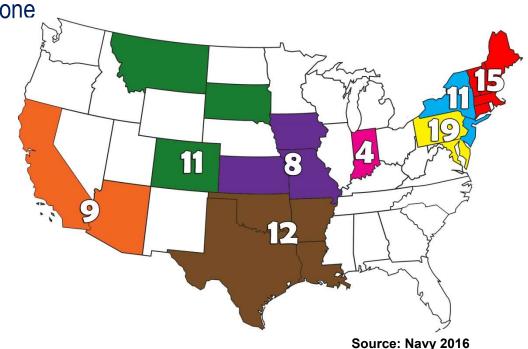
#### **TI Waivers**



- Guidance for Evaluating the Technical Impracticability of **Groundwater Restoration (EPA, 1993)**
- TI Waiver Policy, 1995
  - Only specific contaminants, ARARs

Applies only to established TI Zone

- Decision is regional
- Timeframe is critical
- Difficult to obtain
  - As of 2011 91 TI Waivers
  - Only 8 Federal Facilities



#### **States Regulatory Programs**





- State Programs/Policy
  - Typically follow Risk-Based Corrective Action (RBCA)
  - Low-Threat Closure (California)
  - Texas Risk Reduction Program (TRRP)
  - Florida Risk Management Options (RMO I, II, III)
- State Designations
  - Containment Zone
  - Plume Management Zone (PMZ)
    - Texas (NWIRP Dallas, NWIRP McGregor)
  - Conditional points of compliance
    - Washington, Florida

#### **Groundwater Reclassification**



- Regulatory process
- Multiple states have groundwater classifications
- California
  - Basin Plan
  - SWRCB Resolution No. 88-63 (Source of DW Policy)
    - TDS >3,000 mg/L
    - Yield <200 gpd</li>
    - Contamination
- Navy Examples
  - China Lake
  - NWIRP McGregor



Source: Navy 2016

#### When Are Aggressive Remedies Appropriate?



- Relatively Higher Risk Situations where unacceptable risk is likely to be present (fewer sites)
  - Receptor is already impacted (e.g., supply well impacted or vapor intrusion causing unacceptable indoor air levels)
  - Probability of impact to nearby receptor is high (e.g., nearby supply well and fast-moving groundwater; building on top of shallow subsurface sources)
  - Plume is expanding
  - Plume is migrating towards a drinking water supply well
  - Plume is migrating offsite
- Aggressive treatment is often required for plume control
- Source treatment is worthwhile when remaining plume can be managed with MNA or LUCs alone

#### Passive Remedies and Longer Timeframes



- Relatively Lower Risk Situations where "unacceptable risk" is unlikely to be present
- Sites that pose no excess risk to actual receptors, but ARARs have not been met
  - Plume is stable or decreasing
  - Groundwater is migrating towards surface water
  - Groundwater is migrating towards irrigation/agricultural wells
  - Groundwater has TDS and/or yield characteristics that make it unsuitable for drinking
  - Site contaminants are primarily petroleum related
- Limited source treatment; often coupled with MNA
- Institutional controls to limit exposure and maintain protection of human health and environment

#### **Interim Goals**



- Interim Goals recommended as part of Portfolio Optimization (P-OPT)
- RC-T Type 1
  - •Sites are in monitoring status only; the remaining remedy components include periodic monitoring for trend analysis and land use controls.
  - No unacceptable risks with monitored natural attenuation (MNA), plume is stable or decreasing
- RC-T Type 2
  - Sites are those with the groundwater remedy constructed and is demonstrated to be operating successfully with continued operations and maintenance
  - No unacceptable risks with P&T system or bio-barrier that needs periodic replenishment, downgradient plume is stable or decreasing

## **Key Messages on Complex Sites**



- Approximately 10% of all sites classified as complex (NRC 2013)
  - Navy P-OPT identified a subset of complex sites where it will be difficult to meet restoration goals within 30 years
  - P-OPT identified few opportunities to accelerate remediation timeframes
- Adaptive Site Management identified as most suitable approach for addressing complex sites (ITRC 2017)
  - P-OPT recommended phased technical approach prioritizing sites exhibiting unacceptable risk to human health and environment
  - Life cycle CSM used to guide decision-making throughout restoration process
- Transition assessments to evaluate remedy performance and select new remedies or transition to long-term management (NRC 2013)
  - P-OPT recommended additional RPM guidance on transition assessments and development of new tools
  - Case studies demonstrating successful transition assessments (e.g. NWIRP McGregor)

# **Key Messages (Cont.)**



- Long-term passive management appropriate long-term goal for most complex sites (NRC 2013)
  - Focus remedial efforts on sites with uncontrolled risks
  - Long-term cleanup goals (e.g. MCLs) achieved through natural attenuation
  - Interim institutional controls to prevent exposure
  - Continuously update CSM and optimize remedy
- Interim goals often necessary to guide progress towards overall site objectives (ITRC 2017)
  - P-OPT recommended use of transition goals (e.g. RC-T Type 1,2) to focus initial remedial efforts on unacceptable risks
  - Phased remediation approaches feedback loop, updated CSM

#### **Contacts and Questions**



#### **Points of Contact**

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#### **Questions?**